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CIVIL ENGINEERING
Geotechnical Engineering

BERKELEY, CALIFORNIA 94720

August 20, 1975

STATINTL

Mr. Robert M. Forcey
National Academy of Sciences
National Research Council
Commission on International Relations
Section on USSR & Eastern Europe
2101 Constitution Avenue
Washington, D.C. 20418

Dear Mr. Forcey:

Professor Kenneth L. Lee and I hereby respectfully submit 3 copies of the report on our recent exchange visit to the U.S.S.R..

We also want to use this opportunity to thank you for your kind and considerable help in arranging our trip.

Sincerely yours,

John Lyster
Assoc. Professor of
Civil Engineering

JL/af

Enclosures

cc: Dr. William A. Brown ✓
Professor K. L. Lee

State Dept. declassification & release instructions on file

Report of Exchange Visit to Russia
In Geotechnical and Earthquake Engineering

June 1 - July 1, 1975

Academy of Sciences - USA and USSR

by

Kenneth L. Lee and John Lysmer

University of California

Synopsis and Introduction

During the period June 30 - July 1, 1975 the writers visited the Soviet Union as participants in an official scientific exchange program between the American and Soviet Academies of Science. The purpose of our trip was to familiarize ourselves with Soviet research and practice in the areas of geotechnical and earthquake engineering, and to exchange information with individuals and organizations engaged in advanced studies and research in these fields. Our visit took us to 7 institutes in 5 cities where we held many formal and informal technical discussions. As a general statement, our trip was successful. Nevertheless we do have some reservations due to what we consider to be an inefficient scheduling and use of our time at some locations and our inability to take corrective action in time to improve the situation.

The scheduling and time effectiveness is illustrated by the day to day diary contained herein. The technical benefits are discussed separately. As a means of improving the time efficiency and effective scheduling for future American exchange visitors, it is suggested that the Soviet Academy provide a fairly comprehensive itinerary to the candidate prior to his departure from the United States, and that immediately on arrival in Moscow he be given an audience with an effective person from the Soviet Academy who is in charge of his program where his itinerary will be carefully reviewed and desired changes may be made.

In brief summary, we found the Soviet approach to problems in our field of specialization to be somewhat different to the American methods. The Soviets rely heavily on large scale model tests whereas the Americans use a combination of sophisticated analytical and laboratory test models.

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Our visit was not sufficiently long to permit an in-depth study and evaluation of each other's methods to the same problem. Therefore it is suggested that there be a long-term exchange of a few graduate or post-doctoral students to work in detail in each other's laboratories using both techniques to solve a similar real problem. A particular problem in which we would be interested in working with Soviet graduate students in our universities is the seismic stability analysis of one of the major earth dams currently planned or under construction in the Soviet Union.

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Itinerary and Brief Diary

Sat., May 31, 1975, 4:00 PM (Los Angeles time)

Lee and Lysmer met in Los Angeles Airport and began flight to Moscow via London and Warsaw.

Sun., June 1, 1975, 9:30 PM (Moscow time)

Arrived Moscow Airport and proceeded smoothly through immigration and customs. Met by USSR Academy of Science interpreter and driver who took us to a hotel operated by the Academy.

11:00 PM (Moscow time) Arrived in our rooms. Given R 156.50 and itinerary written only in Russian. Promptly went to bed. (Approximately 20 hours actual travel time from take off in Los Angeles).

Mon., June 2, 1975, 1:00 PM

Refreshed after a sleep and meal, we were met by same interpreter and car and taken back to airport to get Lysmer's luggage (which had been delayed). Later we were taken on a short sight-seeing tour of Moscow.

Tues., June 3, 1975

Free during the day. No contact with interpreter or Academy officials.

9:30 PM. Interpreter and driver met us in our hotel and took us to airport for trip to Tashkent.

Summary Comment on Moscow, Arrival and First Visit

1. No delays or difficulties at airport.
2. Academy of Science interpreter (Alla Faplatina) met us and was most helpful, especially with the problem of Lysmer's delayed luggage.
3. Interpreter was also helpful in booking us into the hotel, giving us money, and taking us sightseeing.
4. We were disappointed, and believe that the effectiveness of our entire visit to the USSR was diminished by the following:
 - (a) Lack of opportunity to meet with any Academy official in Moscow for a general orientation briefing prior to depart-

(b) Our written itinerary was only in Russian, and the interpreter was unable to give more than a cursory translation. All we really got from the written itinerary were the cities and the dates. Important items including times, names of institutes, names of key persons and telephone numbers were not supplied.

Tashkent, Capital of Uzbekistan Republic, USSR

Weds., June 4, 3:00 AM (Moscow time); (6:00 AM Tashkent time) Arrived in Tashkent. No one met us. With assistance from airport officials, contact was made with Academy of Science. We waited at airport from 6 AM to 10:30 AM (Tashkent time) Interpreter from the Foreign Office and driver arrived and took us to hotel. No itinerary was given except promise to meet Institute of Mechanics at 10:30 AM the next day. The remainder of the day was free.

Thurs., June 5 (5:00 PM)

After some delays (some advised by telephone) the Foreign Office interpreter and car met us in the hotel and introduced us to two engineers from the Institute of Mechanics. Then he left. Neither engineer spoke English! By sign language we were directed to the car, then driven to the Institute and ushered into a room containing 10 persons, none of which spoke English. After some embarrassing silence, false starts, sign language, attempts at written communications, etc., two ladies entered who spoke some English. The time was 5:30 PM - almost 4 full days since entering the USSR and our first technical contact! The meeting lasted 2 hours and then adjourned until the next day. They suggested reconvening at 2:00 PM for 1 hour. We requested 10 AM with no ending time specified. We also requested a meeting with the Institute of Seismology but this was denied.

Fri., June 6, 1975, 10:30 AM - 12:00 Noon.

Second meeting at the Institute of Mechanics in Tashkent. This was primarily a tour of their experimental facilities, with a short discussion on analytical methods including finite elements.

Foreign Office interpreter met us at hotel to give us a guided "cultural tour of the city". Explaining that he had no car today, he took us across the street and deposited us in the new Lenin Museum in charge of an English speaking guide. The entire museum is devoted to the life of Lenin and the rise and accomplishments of the Communist Part in the USSR.

Sat., June 7, 1975

Tashkent, completely free. Being advised in advance that this would be a free day, we booked a private sightseeing tour through Intourist to Samarkand located about 4 hours drive by car from Tashkent.

Sun., June 8, 1975

Tashkent. Free. Privately arranged to see a noon ballet performance. Foreign Office interpreter had arranged for an English-speaking guide to escort us through a historical museum depicting significant events of the area from prehistoric times to the present.

Mon., June 9, 1975, 10:30 AM

Foreign Office interpreter and car met us at hotel and took us and luggage on what we had been told would be a driving tour through old historical Tashkent en route to airport. Instead we were deposited at another museum - Museum of Cultural Achievement, in charge of an English-speaking guide for all the time up to departure. This museum was devoted entirely to the cultural, industrial and economic achievements of the Uzbekistan Republic since the Communist Revolution of 1917.

1:00 PM

Left Tashkent for short flight to Dushanbe (about 1 hr.).

Summary Comments on Tashkent Visit

Our visit to Tashkent was frustrating, unproductive and discourag-

ing. To begin, we had been assured by the Moscow interpreter that on the day of our departure Moscow and Tashkent Academy officials had been in telephone communication regarding the exact date and time of our arrival. No one met us at the airport, and when after 4 hours wait someone did arrive, he excused himself saying that we were not expected until the next day.

Our proposed itinerary had specifically requested a meeting with the Institute of Seismology. This was denied us, with the explanation that we wouldn't be interested in what they were doing. Instead we were taken to the Institute of Mechanics which we had not requested. Attempts to change the itinerary and visit the Inst. of Seismology were unsuccessful.

For the first 8 days in the USSR, and during the entire 5 days in Tashkent, only 3½ hours of technical discussions were provided to us. The remainder of the time was either free, or escorted sightseeing tours--usually involving museums devoted to displaying achievements since the Communist Revolution.

We did gain a little useful insight into the activities of the Institute of Mechanics, which will be described in the technical part of this report. However, we learned later in Dushanbe that the Institute of Seismology was a leader in earthquake prediction, and we therefore regret that we were not permitted even a short visit to this institute. The Foreign Office interpreter was not particularly helpful. He fulfilled the bare essentials of his job by meeting us and returning us to the airport, and providing us with some intermittent guidance, but he was generally late for appointments, unreliable and uncooperative in helping to improve the technical content of our tour.

While the various museum tours were informative, we regret that the Academy provided such a large imbalance of time to cultural visits and free time, and so little time for technical work.

Dushanbe, Capital of Tajikistan Republic, USSR

Mon., June 9, 1975 (continued)

About 3:00 PM

Arrived in Dushanbe. Met by 3 persons, all from the Institute

of Seismology, Earthquake Problems and Construction. Taken to hotel for check-in. Then taken for short orientation tour of the city ending with a delightful get acquainted hour at a tea house near the hotel.

Tues., June 10, 1975, 10:00 AM - Noon.

Met at hotel by 2 engineers and 2 interpreters. Taken to the Institute of Seismology for introductory and orientation meeting. Returned to hotel for lunch.

3:00 PM to 6:00 PM

More technical discussions at the Institute with ample interpreters.

6:00 PM to 9:45 PM

We were taken by car on a short sightseeing trip up a small river into the mountains. Two jeeps with others from the Institute also followed. At the end we stopped at a delightful outdoor spot for a sumptuous picnic supper. Returned to our hotel about dark.

Weds., June 11, 1975 - Morning

Technical discussions on USSR methods of seismic stability analysis of earth dams and other topics.
Afternoon.

Lee gave a lecture on the seismic stability analysis of the of the San Fernando Dams, California. Lecture was well attended, about 40 people - full room.

Thurs., June 12, 1975

Morning

Lee and Lysmer split up for specialized technical discussions with Soviet counterparts. Lee discussed seismic stability analysis of earth dams. Lysmer discussed seismic analyses using Releigh wave concepts.

Afternoon

Lysmer gave lecture on finite element methods in seismic analyses of soil and soil-structure problems.

Evening
Lysmer and Lee were invited to dinner at the home of Dr. David Simpson, a visiting seismologist from Lamont Laboratories, Columbia University, who has been in the USSR for about 1 of a planned total of 6 months.

Fri., June 13, 1975 (all day)

Technical tours. In the morning we were taken to visit the following: (i) a high rise building which contains strong motion earthquake recording equipment; (ii) a precast concrete plant and an apartment construction site operated by the same company that builds the precast concrete units.

In the afternoon we were taken to visit the seismological test station located in the open country some 40 km from Dushanbe. There full size or large models of actual structures can be tested under seismic loading produced by large dynamite blasts.

In the evening Lysmer and Lee hosted a dinner party in our hotel dining room for a total of 13 persons who have worked closely with us during our stay in Dushanbe.

Sat., June 14, 1975

In the morning we were taken on a sightseeing trip up a river canyon into the slopes of the mountains where the temperatures were pleasantly cool. The trip ended with a delicious full late lunch at a tourist type restaurant overlooking the river. About 15 people from the Institute came on the trip. The remainder of the day was free.

Late in the evening a high level US government delegation arrived, making a tour of the Soviet Union to inspect some of the projects being carried out in the USSR under various USA-USSR exchange agreements. This delegation was headed by Mr. Train, head of the US Environmental Protection Agency. He was accompanied by Mrs. Train and two teen-age children, and was assisted by Dr. William Brown who also acted as interpreter on some occasions. In anticipation of this US delegation visit our program hereafter had been planned to have us participate jointly with them in some parts

Sun., June 15, 1975

Joined with the Train delegation for a technical tour of the Nurek earth dam and hydro electric station. When completed this dam will be 310 meters high, making it the highest in the world. The power generating capacity will be approximately the same as Grand Coulee Dam.

This tour ended with a sumptuous luncheon at the seismological station at Nurek, whereupon we returned to Dushanbe, a trip of about 1½ hours by car. The remainder of the afternoon was free.

In the evening we were invited to participate in a formal dinner for the Train delegation sponsored by the government and the Academy of Science of the Tajikistan Republic, USSR.

Mon., June 16, 1975

In the morning we attended a formal meeting at the Academy of Science headquarters where the organization, operation and objectives of the US-EPA and the Tajikistan Academy of Science organizations were described by their respective heads.

In the afternoon we bade farewell to our Dushanbe hosts and flew to our next stop, Tbilisi, capital of the Republic of Georgia.

Summary Comments on Dushanbe Visit

After the lack of technical content in Moscow and Tashkent, our visit to Dushanbe was a most rewarding experience. We were given excellent treatment, with a good balance between technical, recreation and free time. In contrast to the previous experiences where for the cultural and recreational outings we were left entirely in the hands of non technical interpreters, or left alone, the several recreational events that were hosted at Dushanbe were attended by many of our technical colleagues. Thus even while relaxing we were able to continue technical discussions and develop close ties that should prove valuable in the future.

Mon., June 16, 1975 (continued)

The flight from Dushanbe to Tbilisi required a change of planes and 4-hour layover at a small city called Mineralwaters. We mention this in passing only to point out the superior excellent treatment we received from the Intourist personnel at this airport during this rather long layover. The Intourist lounge is clean, spacious and comfortable. The Intourist people are friendly and helpful and speak good English. Our dinner was brought up to us and we were personally escorted first out into the plane at departure time.

Of course, like all Intourist waiting rooms, the available reading material consisted solely of numerous Communist propaganda pamphlets.

10:00 PM.

On arrival in Tbilisi we were met by 4 persons from the Institute of Structural Mechanics and Earthquake Engineering, who took us directly to our hotel and made an appointment to pick us up the next morning. We were definitely made to feel welcome.

Tues., June 17, 1975

In the morning we met at the Institute of Structural Mechanics and Earthquake Engineering where we exchanged some semiformal discussions on our respective technical interests and activities. The afternoon was devoted to a city tour under the guidance of technical colleagues from the Institute.

Weds., June 18, 1975

All day was spent on a sightseeing tour of the city and old historical churches in the countryside, hosted and guided by our technical colleagues from the Institute. This culminated in the evening with a modern musical concert in the beautiful new auditorium.

Thurs., June 19, 1975

The morning was spent visiting several experimental departments of the Institute, all located at a research station on the outskirts of the city. These included a prestress concrete department, a department for studying shell structures such as hyperbolic paraboloid roofs and a seismic test facility specializing in shaking table experiments. These departments were all similar in that they were each devoted to research by means of tests on full scale or very large models.

After a late lunch with our Georgian hosts, we had a few hours free, and then spent the evening with them in a walking tour of the downtown streets.

Fri., June 20, 1975

At 10:00 AM we were picked up at our hotel by our hosts and driven to the airport for our flight to Kiev. The plane was delayed for about 1½ hours by technical difficulties. Our hosts remained with us at the airport until we were on the plane.

Summary Comments on Tbilisi Visit

The specific technical content in this leg of our journey was somewhere between Tashkent and Dushanbe: The gracious and unselfish hosting by our Soviet (Georgian) technical colleagues was unsurpassed. We were provided with both technical and cultural tours, but always in the company with several technical colleagues. Most of them spoke English, and there was always a technical interpreter from the Institute present. Thus while we did enjoy a good deal of historical and cultural exposure, our conversation always drifted back and forth to technical matters of our mutual interest. We left Tbilisi with a strong feeling of worthwhile accomplishment, having learned much of what is being done in our technical areas, and in having made good contacts and friends with our technical colleagues.

Kiev, Capital of Ukraine Republic, USSR

Fri., June 20, 1975 (continued)

The flight from Tbilisi to Kiev involved 2 stops, one of

which included a plane change of 1 1/2 hours so that the relatively short distance trip consumed most of the day. We were met in Kiev by an English speaking representative of the Foreign Affairs office, representing the Academy of Science, and taken to our hotel.

Sat., June 21, 1975

We spent the morning working on our notes and drafting our report of the time spent thus far. In the afternoon our English speaking host from the Academy took us on a walking tour of some historical interest parts of old Kiev.

Sun., June 22, 1975

We spent the morning with an Intourist car and guide which we had arranged at our expense, touring parts of both old and new Kiev. In the late afternoon we attended a Ukrainian folk singing and dancing concert.

Mon., June 23, 1975 all day.

At 10:00 AM we were met at our hotel by gentlemen from the Institute of Building Construction and taken to this institute. The visit included a short meeting with the director followed by a tour of laboratories involved in testing models of various types of structures and structural components. At noon we ate lunch in the hotel restaurant with the Institute interpreter, and immediately following we were taken on a tour of some relatively new building construction in Kiev which had been studied on a research-experimental basis at the Institute.

Tues., June 24, 1975

In the morning (10:30 AM - 1:00 PM) both of us gave a summary lecture at the Institute on the various types of research work we were doing at our respective universities. About 30 people were in attendance. Again we ate lunch with our interpreter in our hotel restaurant.

In the afternoon we were given a one-hour tour of the soil mechanics laboratory. This tour was extremely rushed and we had

little time for questions before we were again brought to the directors office for a final formal but very sociable one-hour summary discussion and farewell with the heads of the various laboratories and some other officials from the Institute.

Weds., June 25, 1975

In the morning we were free, and made some more notes, packed, and took a final sightseeing walk. At 1:30 PM a non-English-speaking driver called for us and took us to the airport for our flight back to Moscow which left about 3:00 PM.

Summary Comments on Kiev Visit

The kindness of the Academy interpreter in taking us on a waling tour of old Kiev on Saturday morning, obviously on his own time, was most appreciated. The Institute for Building Construction also devoted considerable time to us during our 2-day visit with them.

However, we were disappointed on two aspects of this visit. Since our technical fields are basically soil mechanics rather than structural engineering, we were disappointed that the visit to the soil mechanics laboratories was limited to only one hour of the 2½ working days available. Although we requested more time for soil mechanics visits and discussions, this was not granted, and we left, having been briefly made aware of a number of interesting concepts in soil mechanics, but unable to appreciate them because of inadequate time for discussion with the soil mechanics personnel.

Secondly, our initial itinerary requested for Kiev included an item concerning a new method of landslide correction being used in the city. As soon as we arrived at the Institute, we asked about this and were told that this problem was handled by another institute. We then asked if they would assist us in trying to arrange a meeting with the institute involved, which they agreed to do. Unfortunately, for reasons which we do not understand, this arrangement was never accomplished.

We had a morning free on the day we left, and could have used

it effectively either in visiting the people involved with the landslide correction or in further discussion with the soil mechanics engineers of the Institute which we did visit, but unfortunately this could not be arranged.

Weds., June 25, 1975 (continued)

On arrival in Moscow we were met by the Academy of Science interpreter who first met us during our first visit, and were taken to our hotel, arriving about 6:00 PM.

Thurs., June 26, 1975

At 10:00 AM we were picked up at our hotel by an engineer from the Institute of Physics of the Earth and taken to that institute. We spent a full and interesting day in discussions with many people on topics of mutual interest. We had lunch with our hosts in the institute cafeteria. Returned to our hotel at 6:30 PM.

Fri., June 27, 1975

All day (from 11:00 AM to 4:30 PM) we spent at the main office building of the Hydroproject Organization. This group is responsible for all hydroelectric and canal projects in the USSR, although some work is delegated out to institutes in the various republics.

We were treated extremely well. Interpretation was excellent. The range of work done by the Hydroproject Organization was briefly described in a short introductory meeting. Each of us then gave a lecture to a group of about 50 of their staff, which was followed by some questions.

After lunch with 3 officials in the company cafeteria, we entertained a few more special questions from 2 engineers who attended our lecture. We were given a comprehensive briefing of the USSR work in tidal power projects, with emphasis on the soil mechanics and foundation point of view.

At the close of the day we were somewhat reluctant to leave because it was clear that there was still much of value yet to be

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learned by us and them. Only in the last few minutes of our visit was the subject of model testing with the aid of a large centrifuge brought up. Our hosts expressed willingness to discuss this interesting geotechnical engineering technique with us but unfortunately there was no time. They did promise to send us some brochures, and offered to discuss this type of work in detail if and when we might return for another visit to the Soviet Union.

In the evening we went with our Academy interpreter to the Moscow Circus.

Sat., June 28, 1975

Spent the morning arranging tickets home, shopping and strolling through central Moscow. In the afternoon our Academy interpreter accompanied us on a visit to a large permanent exhibition where the life and times of the Soviet Union are elaborately depicted in some 70 different pavilions and exhibition halls, as well as beautiful and informative outdoor displays, gardens and fountains.

Sun., June 29, 1975

We spent a quiet day working on our final report of the tour.

Mon., June 30, 1975

A new Academy interpreter came to our hotel at 9:30 AM and we thought he was going to take us to the institute listed on our schedule. He told us that our visit to that institute had not yet been arranged, whereupon he made some phone calls to arrange it. Finally by about 11:00 AM we were told that a visit had been arranged for the afternoon with pickup at the hotel at 2:00 PM.

An enjoyable and beneficial visit was made 2:00 - 6:00 PM to the Institute of Bases and Underground Structures.

Tues., July 1, 1975

At 9:30 AM we were advised that the final visit with the Academy of Science could not be held. Thus at no time during our entire stay in the Soviet Union were we given an opportunity of meeting with our official hosts, the Soviet Academy of Sciences.

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At 11:00 AM an Academy interpreter and car called for us at the hotel and transported us to the airport for our flight departure at 1:30 PM.

INSTITUTES AND SCIENTISTS VISITED

Tashkent

The Institute of Mechanics and Earthquake Engineering, Uzbekistan
S.S.R. Academy of Science. Akademgorodok, U.S.R., Tashkent, U.S.S.R.

Ubaydulla Shamsievich Shamsiev (Director)

Vladimir Tihonovich Rasskazovsky (Manager)

Gaubnazar Hadievich Hoghmetov

Kabul Sadikovich Abdurashidov (Manager of Structures Testing
Laboratory)

Ismail Aliev

Hashiru Kasimovich Kasimov

Abdyrahman Asimovich Ishanhodghaev

Rahima Husnutdinovna Muhutdinova (Computer Specialist)

At the Institute of Mechanics and Earthquake Engineering we discussed or were shown the following items:

1. A forced vibration test set up on a full scale new type of prefabricated roof truss made from readily assembled steel pipe sections. The forced vibrator consisted of a rotating eccentric weight. The control and recording system did not appear to be particularly sensitive. We were not shown any data and were unable to learn details concerning the test.
2. A wooden box 2 x 3 x 1 meter filled with earth and mounted on a shaking table driven by an eccentric rotating weight. An 8 in. diam. pipe was buried in the soil fill. The test arrangement was intended to study soil-pipe interaction and motions during shaking. The instrumentation which we saw looked very crude, and we could not determine the detailed nature or objectives of this test.

3. Seismic instrumentation of the Institute Building. This consisted of: (a) 14 seismoscopes (10 for horizontal motion and 4 for vertical motion). These instruments appeared to be basically similar to the seismoscopes we use in America. Each instrument had a different natural period (Horiz. 0.05 to 1.0 sec; Vert. 0.05 to 0.2 sec).
 - (b) Several strong motion displacement meters with maximum amplitude scales ranging from 15 mm to 150 mm.
 - (c) One set of 3D strong motion acceleration recorders.

The strong motion displacement meters have been used longer and are preferred in the Soviet Union to strong motion accelerometers. We could not ascertain the reason why, except that it seemed to be based largely on tradition.

Our initial proposal for Tashkent requested a visit to the Institute of Earthquake Engineering and Seismology, but did not specifically request a visit to the Institute of Mechanics to which we were taken. When we first learned of this, in Tashkent, we requested a visit to our preferred institute, but for unknown reasons our request was never granted. Later, in Dushanbe, we learned from our colleagues that indeed our first requested institute was a leader in the field of earthquake engineering and earthquake prediction. Thus, because of being unable to visit this institute, our trip to Tashkent was rather disappointing.

Dushanbe

Institute of Seismology, Earthquake Problems and Construction,
Dushanbe 29, Auni 121, Tadj SSR, USSR

Sabir Negmatullaev (Director)

Kamit Mirzoev (Vice Director, Earthquake Prediction, some English)

Anatoli (Tola) Afanciavich Luniov (Construction)

Swiataslav (Slava) Vasiliavich Kozannov (Construction)

Olga Soboleva (Earthquake Prediction, good English)

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Genadij.Sergeevich Seleznev (Earth Dams, some English)
David Simpson (Visiting U.S. Seismologist, Columbia University)
Hadgi Mirzobaev (Geologist)

Main Observations

This visit was the highlight of our tour, technically and otherwise. The institute is divided into two departments, seismology and engineering seismology. The former department has pioneered several methods of earthquake prediction and is currently participating in a joint US-USSR program on this problem. An American participant in this program, Dr. David Simpson, is currently stationed in Dushanbe to study the increased seismicity caused by the filling of the reservoir behind the nearby Nurek Dam.

The engineering seismology department studies problems of seismic risks, structural behavior of structures during earthquakes, and seismic stability of earth dams. This department is also responsible for the collection of strong motion records in the Tadjik Republic. A major topic of research during the last decade has been the seismic stability of the 310m high Nurek Dam. This dam which will be the world's highest rockfill dam has been analyzed by 1/50 scale model tests in which earthquakes were simulated by explosive charges. It was also analyzed by the finite element method and an analog computer model. We had the opportunity to pay a full day visit to the construction site for the dam which is now about 50% complete.

Another unique research program of the engineering seismology department is a series of full scale tests in which 4-story buildings of different types were subjected to strong earthquakes generated by large arrays of explosive charges. To our knowledge, similar tests are performed nowhere else in the world.

Tbilisi

Institute of Structural Mechanics and Earthquake Engineering,
Academy of Sciences of the Georgian SSR, Zoya Rukhadze str. 1,
Tbilisi, USSR.

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Staff contacted:

K. S. Zariiev, Professor, corresponding member of the Academy of Sciences, Director of the Institute of Structural Mechanics and Earthquake Engineering.

Sh. G. Napetvaridze (Professor)

Avtandil (Afto) Kh. Koridze (Senior researcher, seismic risk)

A. (Archil) V. Odisharia (Senior researcher, seismic zoning)

Tengiz I. Gogelia (Junior researcher, finite element analysis)

Main Observations:

The Republic of Georgia has a high seismicity and the Tbilisi Institute of Mechanics and Earthquake Engineering had many things to offer in our area of interest. Our host, Professor Napetvaridze, is a specialist on soil dynamics and seismic design of earth dam and we had a second opportunity to discuss the seismic analysis of the Nurek dam.

Drs. Koridze and Odisharia both work in the area of site response analysis and seismic zoning, and Mr. Gogelia is studying the effects of site conditions using finite element analysis. In these areas we detected a strong influence of previous contacts with U.S. researchers, notably Professor R. W. Clough from the University of California at Berkeley. These contacts were made during an international symposium held in Tbilisi in approximate 1972. All of the researchers in Tbilisi expressed a strong interest in expanding this cooperation between the US and the USSR.

A visit was made to the laboratories of the institute. The notable experiments involved a scale model for the study of transmission of shear forces in floors made from precast T-beams and several scale models for monolithic shells. The institute has recently acquired a rather unique shaking table. This table which measures 6m x 6m can excite 50 ton models in all six rigid body modes (3 translations + 3 rotations). However, only 3 of these modes can be excited simultaneously. The hydraulic exciters

are very strong and an acceleration level of 3g can be reached with light models.

We feel that the visit to Tbilisi was well worthwhile both technically and socially. The success was due mainly to the exceptional efforts made by our hosts who did everything possible to make us feel welcome and to facilitate the exchange of information which flowed freely in both directions.

Kiev

Institute of Building Construction, Kiev

Staff Contacted:

Antone I. Burakas	(Director)
Alexander Marchenko	(Vice Director)
Ivan M. Litvinov	(Professor Soil Mechanics)
Adolf M. Ruzkov	(Properties of Sand and hoess)
Sezgei N. Klepisov	(Differential Settlements)
Guri Simko	(Concrete, shells)
Mark Yankelevich	(Structural Optimization, English)

Main Observations:

This institute is mainly concerned with problems related to building construction. The emphasis being on element construction with large units consisting of several rooms and cable and shell roofs made from concrete elements. Particularly impressive was the model laboratory where large models of the above types of structures were test loaded and evaluated as to stability and effect of differential settlements. As Ukraine is not a seismic area, little emphasis is placed on seismic design. The most interesting structure we discussed at the institute was a circular cable roof for a bus garage. This roof, supported by a single internal column at the center, has a diameter of 260 m. We had an opportunity to see both an experimental model and the completed structure which is most impressive.

The institute has an active soil mechanics group led by Dr. Litvinov who is well known for his portable soil testing equipment.

We inspected this equipment and found it especially suited for dry loess soils. Other projects involve thermo-stabilization of loess soils and deep compaction by means of explosive charges placed in boreholes. These methods appear to be quite effective in dry or partly saturated soils.

Dr. Ruskov is working on a fundamental study of the compaction and strength properties of granular soils.

Dr. Klepisov studies the effect of differential settlements on structures. The settlements, which may be caused by creep, permafrost, or mining subsidence, are simulated both theoretically and experimentally. The latter method involves measurements on full scale buildings which are being undermined by horizontal drill holes.

Moscow

Institute of Physics of the Earth

____ Koridalin (Professor, Deputy Director)

N. V. Shebalin (Professor, Chief of Strong Earthquakes Laboratory)

Yu. I. Vasilev (Dr., Chief of laboratory for explosive sources and soil mechanics)

V. A. Tokmakov (Dr., Seismic Instrumentation)

V. G. Tishenko (Prof., Seismic Investigations)

N. V. Kuzmina (Dr., Seismic Investigations)

Victor Shtejnberg (Dr., Geophysicist)

Main Observations:

This institute deals with all matters concerning the origin and development of the Earth and the other planets. Hence many geophysical disciplines such as theoretical physics, tectonics, and seismology are represented within the institute. Seismology is obviously a main branch and our attention was limited to matters related to engineering seismology.

Professor Shebalin's laboratory for strong earthquake motions is doing some interesting work on the correlation between earthquake source parameters and intensity distributions. This labora-

... is also responsible for the collection of strong motion records in all of the USSR and we brought back with us a collection of such records. Unfortunately most of the records are displacement records and some of them went off scale, such records are not as useful as acceleration records. They are however the only strong motion records available from the USSR.

Dr. Vasilev's laboratory for explosive sources and soil mechanics studies the motions developed near buried explosions. This study has led to a study of nonelastic behavior of unsaturated clays. The data developed relates to the propagation of P-waves and correlates well with the S-wave data developed in the US. This laboratory is also working on an approximate method for estimating the permanent surface settlement caused by subsurface explosions. It is still too early to evaluate the usefulness of this research.

In the Laboratory on Seismic Investigations (Dr. Tokmakov, Tishenko, and Kuzima) we had the opportunity to evaluate several displacement and velocity records obtained at a field station which we previously visited in Dushanbe.

Moscow

Hydroproject

The USSR Ministry of Power and Electrification, Moscow, USSR.
Nikolai A. Malyshev (Deputy Director)
Valery Ja. Sherskov (Chief Engineer) Tele: 155-36-37
Vadim G. Samarin (Research Scientist, English) Tele: 492-72-12
L. B. Bernstein (Chief Engineer - Tidal Power Plant Projects)
W. Ivanischev (Computer - Earth Dams)

This institute or Ministry is in charge of all hydroelectric, earth dams and canal systems in the USSR. Some 3500 persons work at the main office building in Moscow. In addition there are other offices and laboratories in Moscow and in other parts of the country. Hydroproject also work in conjunction with other institutes at various locations on special problems.

During our short visit we each gave a formal lecture, and

then had some personal conversations. We found the staff to be particularly interested in our analytical methods and computer programs for the seismic stability of earth dams. The discussion on this topic was let by Mr. Ivanischev.

Mr. Bernstein presented a review of the Soviet experience with tidal power, and at our request dealt mainly with the geotechnical engineering aspects. He stated that tidal power projects elsewhere, notably in France, were uneconomical because of the high initial construction costs involving building the dike in place. The Soviets have developed a technique of using prefabricated concrete dike sections which are towed to the site and sunk. The foundation at the site is first made level by blasting rock and backfilling with sandy gravel lowered by clamshell from a barge, and finally leveled by large submerged scrapers. One small (400 kw) prototype test station has been constructed thus far, near Murmansk, and plans are being made for additional future larger stations. All of the potentially favorable sites lie in arctic regions posing severe construction and operation difficulties. Two very large somewhat visionary plants were briefly mentioned, both located in the extreme far east. One would export power to North America and one to Japan and South East Asia.

We were disappointed that our visit did not include the large centrifuge model testing facilities of this organization which are used in testing models of large dams. The facility was very briefly described, but the time schedule did not permit a visit to the facility.

Moscow

Institute of Bases and Underground Structures, Gosstroy, Marx Prospect 12, Moscow, USSR.

Boris S. Fedorov (Director) (some English)

Domenik D. Barkan (Professor)

Vyatcheslav A. Ilyichev (Chief, Soil Dynamics Division)
(good English)

Anatoly A. Vasilevsky (English)

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This institute is responsible for research and development in special foundation engineering design problems throughout the entire Soviet Union. A brochure given to us indicates that since its founding in 1931, the institute carried out research projects in 160 cities across the country. Our short visit was mainly limited to discussions on soil dynamics problems. In addition we were taken on a quick experimental laboratory tour where we saw briefly some other work, but there was insufficient time for explanations.

One of the interesting non-dynamic experimental tests we saw was a lateral load pile test being conducted in an indoor soil tank measuring about 20 ft high, 40 ft long and 15 ft wide. The pile was about 18 in. diam. and 20 ft. long. A similar sized soil test facility was also in the same laboratory building, but was not being used at the present time.

Another non-dynamic facility which was briefly described to us, but which we did not see was a 4m diam. centrifuge for model testing, capable of accommodating models weighing up to 200 kg and operating at a circular frequency of 350 rpm. This equipment is used mainly for studying building settlement on various soil foundations.

The soil dynamic problems of greatest interest seemed to be of the machine vibration type, although the institute also dealt with earthquake problems insofar as they related to building foundations. Earth dams and nuclear power plants were beyond the scope of this institute. The foundation vibration problems seemed to be approached on the basis of elastic half-space theory, and we found nothing particularly new or innovative in their work.

The earthquake studies seemed to be mainly concerned with dynamic bearing capacity and dynamic settlement of footings during earthquake. The Soviet Union building code apparently uses a pseudo static approach to the dynamic bearing capacity problem, but this institute is working on several research projects to modify or improve the existing methods of design. This research is based quite strongly on large model or field tests although some small laboratory tests are also used. Although they are well aware of finite element methods, these are not used at this institute.

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When questioned about the pertinence of their research on seismic bearing capacity or settlement they admitted that they knew of no cases where the cause of a building damaged during an earthquake could be traced to seismic settlement or inadequate seismic bearing capacity.

It should be added parenthetically here that we also know of no such cases, and yet many engineers in America are concerned with seismic bearing capacity of building foundations.

The specific soil dynamic research which was discussed or shown to us included the following:

(i) Gravel pile cap.

In order to avoid loss of lateral load carrying capacity should soil settle below a fixed pile cap, field tests have been carried out to study the use of a thick gravel pile cap between the building and the top of the pile.

(ii) Cone shaped pile tips.

These are being studied as a means to increase seismic bearing capacity in soils with a strong upper crust underlain by softer soil. However, it was not clear to us how they were effective.

(iii) Soil-pile skin friction under cyclic loading.

We saw a pull out test on an 18 in. length of 8 in. diam. pile buried in soil in which the lateral earth pressure was subjected to sinusoidal cyclic loading.

(iv) Seismic shear strength.

We saw a cyclic load laboratory triaxial test set up used to evaluate the seismic shear strength of soil. The explanation was not completely clear, but it appeared that a low amplitude axial load was superimposed onto the regular static load used to fail the sample. We were also told that the cell pressure could also be cycled.

The data were plotted on the conventional Mohr diagram as used for standard static tests. An empirical correlation has been developed equating the design earthquake intensity with the laboratory vibratory loading intensity. The average results indicate that the angle of internal friction reduces as the seismic inten-

sity increases as follows:

<u>Seismic Intensity</u> <u>(Russian Scale)</u>	<u>Reduction in ϕ</u> <u>(degrees)</u>
≤ 6	0
7	2
8	4
9	7

Note the Russian intensity scale is similar to the MM intensity scale at large intensities.

(v) Soil liquefaction.

None of the people interviewed felt confident to speak on this topic. However, it is one of the concerns of the institute, and they promised to send some literature on this subject.

(vi) Soil viscosity under seismic shaking.

Professor Barkan has done no further work in this area since publication of his book (which is well known in America).

General Conclusions

This institute appears to have much to offer American visitors. We were only able to cover a small part of their work in the 1/2 day available to us and it was with regret that we could not spend more time at this institute. Particularly we would have liked to visit the centrifuge model facility and also to learn more about the very large tests conducted in the huge soil tanks. We would also like to have learned about the soil liquefaction studies and to learn more details about the seismic bearing capacity and settlement studies which had to be glossed over because of lack of time.

On the other hand, from what we did see in sufficient detail to judge, we found little that appeared to be outstandingly new or novel to us. Thus, while an extended visit with more detailed discussions would certainly have been of interest, it is not immediately clear that significant new knowledge or techniques would have been revealed.

Non Technical Highlights

In spite of the difficulties encountered, and in addition to the technical aspects of our visit, it was strongly evident to us that the Soviets welcomed us to their country and wished us to have an enjoyable and beneficial time. These impressions were felt in several different ways. Some of them are indicated below.

1. Academy Interpreters.

In Moscow and in the other cities, we were always provided with an interpreter, and often with a car and driver. These facilities were not simply limited to technical visits or airport transportation, but also included sightseeing.

Outstanding in this aspect was the Moscow interpreter, Miss Alla Faplatina. The day following our first arrival in Moscow she took us for a tour of the city. During the evenings and weekend of our return to Moscow she took us for a tour of the city. During the evenings and weekend of our return to Moscow she took us to the circus and to the large permanent exhibition, and offered to be of even further assistance should we desire. It is not clear to us how much of this was on her own initiative and how much was sponsored by the Academy. We feel that both were involved.

Similarly, in Kiev our Academy interpreter, Mr. _____ Bondachuk took us on a half-day walking tour of the old city and its historical churches. This was on Saturday, and appeared to be done on his own initiative.

Whether by their own initiative or through the Academy, we were very appreciative of the kindness and assistance of these interpreters.

2. Institute Personnel.

At several of the institutes which we visited we were given an exceptionally hospitable welcome and social treatment. These activities included luncheons, dinners, city tours, visits into the surrounding countryside. In these cases we were accompanied by several technical colleagues who either spoke English or had an interpreter. Thus friendships were established among technical people, and the impromptu dis-

cussions throughout these visits led to better understanding in both cultural and technical aspects.

Efficiency Considerations

Throughout our trip we were constantly asking ourselves whether the value being gained was balanced by the time and money expended. Of course there are many items for which value cannot be assigned, and many aspects which may pay unexpected dividends sometime in the future. Nevertheless, there are also many aspects which can be evaluated with reasonable accuracy in terms of time or money. In terms of expenditures the following estimates seem to be fairly realistic.

Values for each person (two persons involved)

Calendar time - 33 days

Direct and indirect expenses of the Academy of Sciences

(USA and USSR) \$5,000

Loss of personal summer salary \$1,500

In addition, each institute visited made an investment of time of their members involved as well as some money for local transportation and entertainment, etc., while we also devoted considerable time in planning this trip.

A tabulated breakdown of the time spent is shown below.

	days
Travel to and from USSR and sleep	4
Travel within USSR	4 1/2
Weekends - no technical work	7
Free, not weekend, but no technical work	3
Technical visits	14 1/2
	33

Note that in terms of days, not quite half of the time was spent in technical visits, while the rest was either travel or free. However, as indicated in the day by day log included herein, the one-day technical visits were really only something like 4 to 5 hours long. Thus, less than one-third of our potential working time was actually spent in productive technical visits with Soviet Scientists.

In our opinion this benefit to expenditure ratio was considerably too low while there were notable examples of high and low benefit, we feel that from an overall point of view the trip was inefficient and involved an excessive expenditure of time and money for the return achieved.

Hindsight being better than foresight, we have the following suggestions from our experience that should make future similar visits more efficient and effective.

1. Review schedule and itinerary with the visitor in the USA before he leaves.

The Soviet response to our initial proposal came only about 10 days before our departure and consisted of a telegram listing only the cities we were to visit. Although we noted discrepancies with our initial proposal, they were not major, so we did not request clarification. We believe this was a mistake on our part, and we should have insisted on a more detailed itinerary of institutes as well as cities to be visited, and times to be spent in each.

2. Review of schedule with the Soviet Academy on arrival in Moscow.

We were met in Moscow by a capable Academy interpreter and left for two full days without ever being given the opportunity to meet with any other Academy official. We were handed a day-by-day itinerary, written in Russian, which listed the institutes we were to visit. The interpreter gave us a rough translation, but we could not positively distinguish all of the institutes. No hourly time schedule was provided. After 2 free days in Moscow, without being given the opportunity to meet with any Academy official to discuss our program we were sent on our circle tour to the various outlying cities.

This was mistake No. 2. Although we did ask, we were not sufficiently persistent in getting an interview with an Academy official before leaving Moscow. Our trip could have been much more fruitful and enjoyable if we could have had a 2-hour discussion briefing and planning meeting with the Academy official responsible for our visit prior to leaving Moscow. We found out

later that our interests and those of the assigned institutes were not always well matched, whereas other institutes we wanted to visit were not included. We found it impossible to make changes, even within the same city, and even if there was sufficient time. It seems clear that these arrangements must be made from Moscow, and therefore a complete briefing is essential with the Academy in Moscow before leaving for the outlying cities. For example, in Tashkent we spent only 3 1/2 hours in technical visits to one institute during the 2 1/2 weekdays (plus weekend) which we spent in that city. These hours were spent at an institute we had not requested to visit, yet our repeated requests to visit the institute we had originally planned for were never granted.

3. Travel times.

In general a full day was assigned for each inter city trip even though the flight was only 1 to 3 hours long. More efficient scheduling could have been worked out using late afternoon or weekends for travel, and technical sessions in the morning. We recommend the use of late evening flights during the summer in view of the unbearable heat in unventilated Aeroflot aircrafts waiting for take-off.

4. Institute visiting times.

The general pattern followed at each institute was a hotel pick up in time to reach the institute at about 11:00 AM, and departure from the institute at about 5 to 6 PM, with 1 to 2 hours for lunch. On 2 occasions we were invited to lunch in the institute cafeteria, where we could continue discussions with our host during the lunch break, but usually we were returned to our hotel to fend for ourselves. Thus, after removing the formalities of greeting and saying goodbye, there was only about 4 to 5 hours for each institute, and this often involved visits with several different people.

It is felt that with a little care, a more efficient use of time could be arranged, for example, simply by starting earlier in the morning.

We approached each institute uncertain of whether or not we would be expected to give lectures, and which type of specialities would be discussed. Some advance schedule or itinerary would have been appreciated and would have made the visit more beneficial to both the Soviets and to ourselves.

6. Lectures and illustrated slides.

In the application for our Soviet visit we had been requested to list lecture titles we would be prepared to give while in the Soviet Union. Hence, prior to our trip we spent considerable time and effort in preparing for these lectures, including the making and collecting of many 35mm color slides to aid in the presentations.

During our entire visit we were invited to give only 3 formal lectures. The slide projectors which were available were rather inadequate so that the slides could be read only with difficulty by those in the first few rows.

We could have saved ourselves a lot of bother and could have made our presentations much more interesting and effective to our Soviet hosts had we been advised in advance of this situation--especially if we had known that only 1 lecture at each of 3 institutes was all that was wanted.

7. Hotel reservation and airport pick-up.

Prior to leaving each city, the Academy should provide the American visitor with the name of the hotel and the telephone number of the contact person in the next city. This became abundantly clear on our first trip--Moscow to Tashkent. This was a midnight flight, arriving in Tashkent at 6:00 AM local time. We had requested the above mentioned information before leaving Moscow, but were assured that we would be met in Tashkent, and the information was not given to us.

On arrival in Tashkent we were not met. With the help of Intourist we learned that the Academy office did not open until 10:00 AM, so we had no choice but to remain in the waiting room

until at least that time. Finally, about 11:00 AM the Academy representative arrived and took us to our hotel. Had we been given the hotel information we could have gone to the hotel by ourselves, and obtained the sleep deprived us due to night travel.

8. Feeding ourselves.

The simple act of feeding ourselves, became one of the most persistent nagging difficulties in our tour. Talking with other travelers both foreign and Soviet, we found that our experience and our reaction was typical. Because of shortages of restaurant facilities there are always lines of people waiting at every location from the small 4-table cafes to the best tourist hotel in the city. The smallest sit-down breakfast requires at least 1 hour while a full but simple lunch or dinner may take 1 1/2 to 3 1/2 hours including waiting, service and eating. To minimize these delays somewhat we adopted the habit of eating only 2 or even 1 meal per day, and occasionally supplementing this with small purchases of bread or ice cream from street vendors, where the lineup was not so long as in restaurants.

We estimate that with the difficulties and precautions outlined above our meal times required at least 2 hours more than would have been required for a similar trip in the Western Countries we have previously visited. This is time completely wasted, and over the duration of our trip amounted to some 3 full (24 hour) days. In fact, the time wasted in waiting to eat amounted to about one-half of the actual time spent in technical visits.

Summary

Considering the total cost outlay, plus the time wasted in inefficient scheduling and other difficulties, this trip was a very expensive undertaking. While we realize that some aspects are beyond immediate control, we feel that the cost/benefit ratio of these type of exchange visits could be greatly improved by consideration of some of the problems we have cited. Specifically we feel very strongly that the U. S. Academy of Science should insist on a fairly complete schedule and itinerary to be supplied by the Soviet

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and comment on it prior to his departure from the United States. We further feel strongly that every American exchange visitor should be briefed at the USSR Academy in Moscow immediately after his first arrival; where his trip is discussed and where important changes can be worked out if desired.

At the same time efforts should be sought to alleviate the other problems which we have mentioned, by encouraging the Moscow Office to work more closely with the Academy's in the various cities.

Possible Future Exchanges

One of the topics we kept in mind throughout our tour was the desirability of possible future scientific exchanges and detailed cooperative work in specialized subject areas. In so doing we concentrated our attention on subject areas on which we felt some personal expertise, thus eliminating many other areas such as structural dynamics, shell structures, geophysics and earthquake prediction. Many of these areas were of interest to us, but we did not feel qualified to judge whether or not significant benefits could be gained by further indepth cooperative studies.

The most attractive subject area which attracted us was the seismic stability analysis of earth dams. The Soviets have recently completed a thorough seismic stability analysis of the 310m high Nurek dam which when completed will be the highest earth dam in the world. Furthermore, it is being constructed in a zone of relatively high earthquake activity. (Russian intensity of 9 on a scale of 12, corresponding to shaking in the epicentral zone from a Richter magnitude of 6.5) In addition, analysis and design work is currently underway on another major earth dam which will be higher than Nurek. This is the planned 340m high Rogun dam which will be built near the Nurek dam and also in a zone of high seismic activity.

The Soviet method of seismic stability design is completely different from that being used in the United States. The Soviets make extensive use of large model subjected to various types of

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Forced vibrations with local calculations with soil parameters obtained from laboratory tests on small samples.

For example, three different size models were used to study the seismic stability of the Nurek dam as shown below.

<u>Model</u>	<u>Scale</u>	<u>Height of Model</u>	
(a)	1/300	1 m	Shaking Table
(b)	1/200	1 1/2 m	Shaking Table
(c)	1/50	6 m	Field blast tests

The two smaller models were built on a shaking table and subjected to sinusoidal horizontal vibration. The largest model was a small dam constructed in the field and dynamically excited by means of controlled dynamite explosions.

The quantity and details of the explosion testing on the 6 m high model were impressive. The blast holes were located about 40 to 60 m from the dam so that the seismic wave reaching the dam would be essentially plane. The quantity of dynamite used ranged from 4 tons to 4000 tons using delay time caps to produce several seconds of seismic loading.

The observations from these tests included the period of vibration for several modes, showing how it varied non-linearly with excitation level, cracks and permanent displacements. From these tests the Soviets deduced that the effect of the design earthquake on the completed prototype 310m high Nurek dam would be as follows:

Maximum vertical settlement of the crust	3.0 m
Lateral movement downstream	1.0 m
Width of cracks at the crest	20 cm
Depth of cracks at the crest	15-20 m

The Soviets also performed pseudo static analyses, and for the design earthquake found that the theoretical factor of safety by that method would be less than 1.0. Nevertheless they reasoned that the model test results were more reliable than the pseudo-static analysis, and elected to build the dam.

These studies described above were done in the years 1964-65,

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but they appear still to be using the same method in use in the USSR. Nevertheless, their researchers are beginning to use analytical calculation procedures similar to, but less sophisticated than those used in America for seismic response analyses of soil structures like earth dams on foundations for nuclear power plants. However, they seem not to have the computer capacity required to perform these American type of analyses. Furthermore, they seem to neglect almost completely the laboratory testing of soil samples as required by the American procedure in order to obtain the empirical viscoelastic and seismic strength data for the particular soils involved. In the U.S. we do not use model tests for design purposes. We feel that the scaling laws for soil are so complicated that reliable design results cannot be obtained from small shaking table studies; and large scale field models are too costly, too time consuming, and also more uncertain than analytical methods plus special laboratory soil property tests from small samples. The American preference to analytical design methods is also based on experience gained from thorough post earthquake analyses of several older dams which have been severely damaged during earthquakes. These studies have in effect been large full scale model tests which have been carefully studied to check the analytical procedures.

Nevertheless, although some post earthquake analyses of dams have been done, there is a lack of available cases of suitable dams which have been subjected to strong earthquake shaking, and for which data is available. For this reason it would seem desirable to cooperate with the Soviets in some of their studies of seismic stability of large earth dams.

From the Soviet point of view such cooperation would assist them in gaining an opportunity and experience in the American method. From the American point of view such cooperation would provide data from larger field models which could be analyzed as actual small dams, and the calculated results compared with the observed performance of these large scale models.

Our experience as university teachers and researchers has indicated that serious detailed research work in our country is

done mainly by graduate students working on Ph.D. degrees under the direction of an interested faculty advisor. Thus, a formula for the most probable chance of success in this cooperative project could involve bringing two or more Soviet graduate students to our universities for about 3 years to earn Ph.D. degrees under our direction, and then return to the Soviet Union to work with and teach other Soviet Scientists in the technology they had gained. In addition, it would be necessary for the faculty member or principal investigators of the project to make 1 or 2 short trips to the other country to set up the program of research and assure that it followed a direction that was mutually beneficial to both countries. For example, for the earth dam study described above, it would be necessary to send to the American university soil samples, drawings and test data from the actual Soviet dams being studied. Also the principal investigator as well as the student should have a thorough understanding of the basis of the original data, which can best be obtained from an actual visit to the test site, preferably during the testing.

On the other side of the exchange program, we also feel that it would be beneficial for a few of our American graduate students to obtain a Doctoral Candidate degree (roughly equivalent to our Ph.D.) from a Soviet university and research institute. This need not be in the field of seismic stability of earth dams per se, but there are several related areas where the Soviets are doing interesting work not being done in America, which would form a good basis for an American graduate student research topic. For example, earthquake prediction, large scale model tests using explosives, or model tests using a centrifuge. If the American student were carefully selected as one having good potential for continued research and development and good written and oral communication facility, then on his return to America he would be a great asset to his profession in particular as well as to Soviet-American relations in general.

If a doctoral student interchange is not possible (which would require about a 3-year tenure) then a second best alternative would be for an extended Postdoctoral exchange. In this case the exchange

participants should have a fair working knowledge of the other language, and should plan to stay a minimum of 12 months and preferably longer, working in the other country.

Finally, as a third choice, a 6-12-month visit by a senior person such as a professor on sabbatical leave would be useful. However, it is our experience that the higher the level of seniority of the exchange visitor, the more he is prone to look at general concepts and the less he is inclined to truly work with and master the necessary intricate details. For this reason we feel that the general concepts can be adequately covered with 1 or 2 very short (10-15-day) exchange visits of the principal investigator, but the detailed work which will make possible a real furtherance and interchange of knowledge can only be accomplished by post graduate research students who are motivated and dedicated to obtaining their advanced degrees.

For earth dam projects, it appears that the best Soviet contacts would be the Institute of Seismology in Dushanbe and the Hydroproject organization in Moscow. Some very preliminary discussions were held on this subject with senior people of these institutes, and they expressed cautious interest, pointing out that in the Soviet Union such decisions must be carefully coordinated through the Academy of Science. It is intended to continue these discussions with Mr. S. Negmatullaev, Director of the Seismological Institute in Dushanbe when he visits California later this year.

Summary and Conclusions

As stated in the initial request letter from Mr. Handler, President of the American National Academy of Sciences, to Mr. Keldysh, President of the Soviet Academy of Sciences, the purpose of our visit was to "familiarize ourselves with Soviet research and practice in the areas of geotechnical and earthquake engineering..." Prior to our visit there had been very little professional contact and scientific exchange in these subject areas. In about 1959-1960 there was an exchange of a group of scientists and engineers on the subject of highway construction which emphasized

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geotechnical engineering. Some of our acquaintances who are very senior engineers participated. Then in August 1973 an International Conference on Soil Mechanics was held in Moscow and attended by about 2000 delegates from all countries including many from the USA. Unfortunately, according to reports from the American delegates, there were so many people at this conference that personal acquaintances and specific technical exchanges were almost impossible beyond those included in the formal conference program. Thus it was with considerable anxiety that we approached this trip, not only hoping to benefit ourselves and our personal research interest, but also hoping to bring back information to benefit our colleagues and our profession.

Some of those who had previously visited the Soviet Union, especially our colleagues who attended the recent International Soil Mechanics Conference in Moscow, had alerted us to difficulties we might face in trying to accomplish our objectives. Thus, although we were not fully prepared, we were at least aware that this type of trip to the Soviet Union would probably present more difficulties than if it were being made to almost any other country. Now at the conclusion of our trip we more fully appreciate what our colleagues were saying, and yet at the same time we feel that the trip has been both personally and beneficially worthwhile.

While it would be misleading to state that all had gone well and that we had succeeded in our objectives beyond our hopes, on the other hand, we can truthfully state that much of the trip was enjoyable and technically beneficial.

The Soviet Academy of Sciences provided good to very good assistance with travel, lodging and securing appointments within the Soviet Union. Our hotels were always comfortable and convenient. The local transportation and interpretation and assistance at airports, etc., was always good.

However, the Soviet Academy could have made our trip better by two simple and specific procedures.

1. Prior to leaving the USA we feel that we should have had more communication from the Soviets than the two line telegram we received only a few days before our departure, listing only

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the cities to be visited. The communication should have also at least listed institutes to be visited, and a time table schedule. On the advice of our American Academy contact we had written personal letters to several Soviet persons and institutes we hoped to visit, but received no reply either directly or through the Soviet Academy of Sciences. We were therefore embarking almost blindly on a 1-month trip with no assurance that our requested visits would be granted. As it turned out some of our requests were not granted. In a more serious case, it is conceivable that such omissions would have made a trip completely unworthwhile. Thus it is recommended that for future exchange trips such as ours, the American Academy strive hard to provide the traveling American Scientist with a more detailed trip plan than we had prior to his leaving the United States, and in time for him to request modifications or to cancel his trip without prejudice if the schedule looks to be too unsatisfactory.

2. Immediately upon arrival on Moscow we feel that we should have met with the Soviet Academy official in charge of our trip, been given a detailed itinerary, and had an opportunity to discuss and request modifications at that time. As it turned out we spent 2 free week days in Moscow in which our only contact with the Academy was an interpreter. We were handed an itinerary, but it was written in Russian, and the interpreter could not give a clear translation of the names of the institutes listed thereon. We were not given an opportunity to discuss this itinerary with any Academy official. After leaving Moscow we found that in one case we had been sent to the wrong institute, and in some cases the time schedule for travel and visits was poorly arranged so that much time was wasted. Furthermore, our weekends were always free. We would have been willing to pay for various sightseeing trips ourselves, but these were difficult to arrange. Assistance from the Academy in making suggestions and in helping to arrange worthwhile free weekend activities (at no cost to the Academy) would have been greatly appreciated and made our trip person-

ally much more enjoyable.

We must add here that on some occasions the Academy interpreters did go out of their way on their own initiative to show us things of cultural interest. Also some of the institutes we visited also provided some ad hoc sightseeing and other entertainment, so that we did manage to mix some pleasure with business.

We found the institutes in general, and the individual scientists in particular to be very open, accommodating and cooperative in answering questions and providing information concerning their work. Unfortunately because of the rather strict organizational structure of technical responsibilities and the limited time available at some locations we were sometimes unable to speak to the proper persons to obtain the information we desired. However, when with the persons we did speak to, there was considerable generosity and expressed desire to exchange scientific information.

For example, although we visited two institutes which owned and used centrifuges for model testing, we were unable to visit the facilities or to get any detailed information. This was apparently because we had not specifically requested to discuss this specific aspect of geotechnical engineering in our original proposal. Therefore the people involved were not immediately available, and those who did speak with us claimed that they were not sufficiently well informed to provide useful information. Time schedules and other administrative bureaucracy did not permit last minute changes in schedules to allow these visits.

Similarly, although we spoke to several geotechnical engineers, they were all specialists in a narrow field and were unable to give us any useful information concerning simple routine operations such as soil compaction or site investigation. We had not thought to specify specific items such as these thinking that anyone in a geotechnical oriented institute could readily provide useful information on such basic topics.

On the other hand, because we had mentioned a desire to know something about tidal power plants, we were granted an hour or more personal interview with the leading Soviet engineer (perhaps the leading engineer in the world) on this subject. This was much

more information than we could usefully assimilate.

From this experience we learned that it is necessary to be quite specific in specifying in advance exactly what topics or questions you wish to discuss with the Soviets. There appears to be no reluctance on their part to discuss any technical question, but one must first manage to get an interview with the right specialist, and not just the organization.

We found the Soviet scientists to be generally less interested in our work than we had imagined. Although they listened and asked certain questions, it was clear that in most cases they were not exceptionally eager to extract a lot of information from us. For example, we were only asked to give 3 formal lectures on specific topics, and one other general survey lecture. However, there were a few exceptions as will be mentioned.

It appears to us that the reason for this apparent mild interest on their part is similar to our own less than enthusiastic interest in much of their work that we saw. For one thing, we were often somewhat mismatched in the people or institutes to which we were assigned. For another thing, even where the specific goals were identical, our respective approaches were so fundamentally different that it was hard to find meaningful common ground on which to base a serious technical discussion.

Several examples:

- (i) We met several people involved with earthquake prediction, and while this subject is of general interest to us, we are not actively working in this subject area.
- (ii) The Soviets use degree of intensity to define a design seismic loading condition whereas Americans use earthquake magnitude and epicentral distance. It is difficult to relate the two approaches.
- (iii) The Soviet strong motion earthquake recorders are mostly displacement meters whereas the American recorders are all accelerometers.
- (iv) The Soviet engineers use large scale models extensively for research and design purpose, supplementing the data so obtained with semi-empirical or approximate theories and a

minimum of individual specimen laboratory testing. On the other hand, Americans scarcely ever use large scale models, but rather make extensive use of elaborate analytical and laboratory specimen testing.

- (v) Most analytical techniques in the Soviet Union appear to be based on the simplifying assumptions of linear elastic or at most bi-linear elastic models whereas the current American approach more complicated and (hopefully) more realistic non-linear assumptions in the analytical models.
- (vi) The computer facilities available to Soviet scientists in our area of interest are quite limited, forcing them to use smaller programs that preclude elaborate allowance for complicated soil and structural behavior. On the other hand, most American engineers have access to large capacity computers and their research is therefore geared to take advantage of these facilities and use elaborate analytical modeling techniques.

Nevertheless, there were several exceptions, generally involving one or two younger Soviet scientists who read American literature and were endeavoring to use some of our techniques. In these cases very detailed and comprehensive discussions developed and the Soviet scientists were extremely eager to obtain information from us. This was especially the case with analytical calculation methods involving finite elements used for calculating the seismic response of soil masses and soil-structure interaction problems.

In conclusion, we feel that trips such as ours are necessary and worthwhile undertakings. They provide an opportunity for immediate exchange of technical information and they tend to promote friendships which in the long run may lead to further exchanges and better understanding. In spite of some difficulties, we feel that our visit to the Soviet Union was worthwhile in both aspects. We have certainly broadened our own knowledge and understanding of Soviet methods and techniques in areas pertaining to our technical field of interest, and we have developed friends and contacts which may enable future technical exchanges to be carried out more effectively. Furthermore, if our suggestion for some

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long term exchanges at the doctoral student or postdoctoral level can be accomplished we feel that some really significant technical advances in both our countries will follow.

In final conclusion, we express our sincere appreciation to the American and Soviet Academies of Sciences for making this trip possible.

Kenneth L. Lee

John Lysmer

August 20, 1975

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